NOAA National Centers for Environmental Information Topo-Bathymetric Digital Elevation Models: Southwest Florida

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Introduction

This report summarizes the creation of a suite of tiled digital elevation models (DEMs) developed for southwest Florida in 2017 by the NOAA National Centers for Environmental Information (NCEI; Fig. 1). This work was funded by NOAA NCEI Stennis, MS to support data development and coastal modeling in the Gulf Coast.

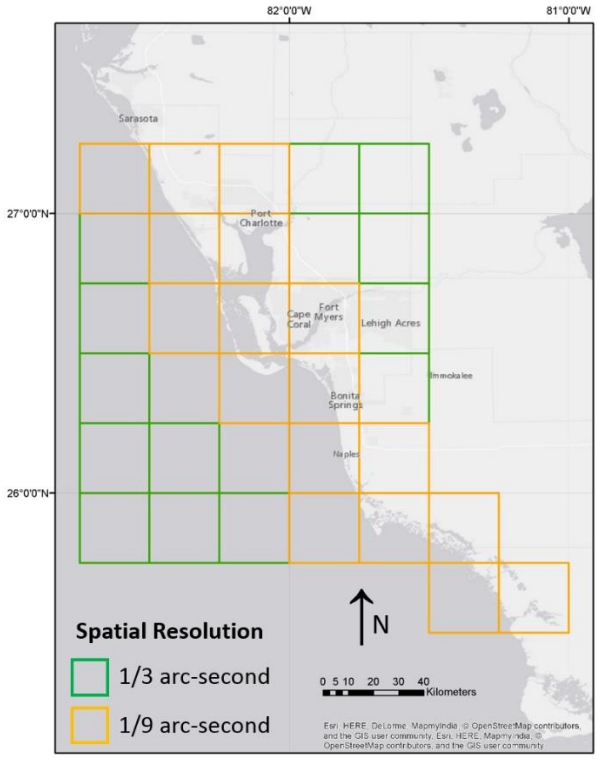


Figure 1. Spatial Extent of the 2017 NOAA NCEI Southwest Florida Tiled DEM suite. Note that only 1/9 arc-second DEM tiles integrate topography and bathymetry.

The DEMs have been built according to specifications developed jointly by NOAA NCEI and the United States Geological Survey (USGS) to better define a consistent elevation mapping framework for the nation (Eakins et al., 2015; Table 1). Overall, 33 tiled DEMs were created in the area of interest: 17 tiles were created at the highest resolution of 1/9 arc-seconds, and 16 were created at a resolution of 1/3 arc-seconds. Only 1/9 arc-second DEMS tiles integrate topography and bathymetry. The DEM tiles represent best available data at the time of their creation; the intent is to update specific tiles as new source data becomes available. The utilization of a tiling

scheme in developing the DEMs is intended to improve data management during source data processing, as well as facilitate targeted DEM updates.

Table 1. DEM specifications of the southwest Florida Tiled DEM suite (from Eakins et al., 2015)

Projection	Local UTM Zone		Geographic				
Cell size	1 m	3 m	1/9 arc-sec	1/3 arc-sec	1 arc-sec	3 arc-sec	9 arc-sec
Offshore coverage	1 nm	3 nm	3 nm	24 nm	500-m depth	200 nm	ECS, LMEs
Grid registration	Pixel						
Horizontal datum	NAD 83						
Vertical datum	NAVD 88				Sea level		
Edge precision	3 m		0.01 degrees (36 arc-sec)				
Elevation precision	0.01 m		0.1 m			1 m	
Multi-temporal	yes		No				
Surface type	Bare earth						
Restrictions	None/Public						

The final integrated 1/9 arc-second topography-bathymetry DEM tiles and 1/3 arc-second bathymetry and topography tiles are referenced horizontally to the North American Datum of 1983 (NAD83) and vertically to the North American Vertical Datum of 1988 (NAVD88).

Data Processing

Original source topographic and bathymetric data were collected by a variety of agencies, including federal, state and local governments. Source data were obtained in a variety of different formats and referenced to disparate horizontal and vertical datums (Table 2).

Table 2. Source datasets used in the creation of the NOAA NCEI southwest Florida Tiled DEM suite

Source Dataset	Data Type	Acquisition Date	Horizontal Datum/Projection	Vertical Datum	Notes
Florida Division of Emergency Management (FDEM): Southwest Florida	Topographic Lidar	2007	NAD83	NAVD88 (geoid 12a)	
Southwest Florida Water Management District Lidar	Topographic Lidar	2005-2006	NAD83	NAVD88 (geoid 12a)	2005-6 Peace River South District; 2006 Upper Myakka District
U.S. Army Corps of Engineers (USACE) National Coastal Mapping Program (NCMP) Topobathy Lidar	Topographic-Bathymetric Lidar	2004-2015	NAD83	NAVD88 (geoid 12b)	2004 Gulf (AL, FL, MS); 2004 Post-Ivan (FL); 2006 Post-Wilma (FL); 2010 Gulf Coast (FL); 2012 Fort Myers (FL); 2015 Florida Gulf Coast
United States Geological Survey (USGS) Coastal Lidar: Post-Charley	Topographic-Bathymetric Lidar	2004	NAD83	NAVD88 (geoid 12a)	
NOAA NCEI Multibeam Database	Multibeam bathymetry soundings	1999-2003	WGS84	Instantaneous Water Level	USF1999, USF2000 , USF2001, USF2001Mudhole, USF2002Fla, USF2003Pulley
NOAA National Ocean Service Hydrographic Survey Data	Bathymetric soundings	1866-1981	NAD83	MLLW	

All source data were converted to a common horizontal (NAD83) and vertical (NAVD88) reference system using the Geospatial Data Abstract Libraries (GDAL) utilities and the NOAA VDatum software utility, respectively. The vertical datum of bathymetric datasets referenced to Mean Lower Low Water (MLLW) were converted to the NAVD88 (Geoid12B definition for consistency with topographic data already referenced to NAVD88. No conversion occurred among topographic datasets referenced to NAVD88 Geoid12A, as Geoid12A and Geoid12B are equivalent, except in Puerto Rico. Multibeam bathymetry, which in most cases was obtained

uncorrected with regard to the water level at the time of data acquisition, was left as such (i.e., Instantaneous Water Level). The magnitude of the differences between various tidal datums and NAVD88 was assumed to be well within the measurement uncertainty associated with the multibeam data (Appendix I).

All data were converted to a common data format (ASCII xyz) in preparation for gridding. If a dataset was obtained in a raster format, it was resampled using a bilinear resampling algorithm to match the target spatial resolution of the affected tile, then converted to ASCII xyz using GDAL. All data was reviewed and evaluated for internal and external consistency with adjacent data. Anomalies in datasets were removed through visual inspection and automated filtering.

MB-System's 'mb-grid' utility was used for all gridding processes. A tensioned thin-plate spline algorithm was used to interpolate depth values in pixels within the DEM extent that were unconstrained by elevation measurements. Constrained pixels were assigned a final elevation value based on the Gaussian weighted average of the input source elevation measurements.

For all tiles with bathymetric data, an initial bathymetric surface was created using the source bathymetry (See Carignan et al., 2011 for a detailed description of the process).

For tiles that did not integrate bathymetry and topography, the smoothed bathymetric surface is the final product. In cases where both bathymetry and topography are mapped, the smoothed bathymetric surface was converted to ASCII xyz and included as an additional dataset to create the final seamless bathy-topo elevation surface using MB-System's 'mb-grid' utility. The bathymetric surface was initially gridded at a spatial resolution of 1/3 arc-seconds, then resampled to the target resolution of 1/9 arc-seconds for integrated bathymetric-topographic tiles.

Final DEM tiles were qualitatively evaluated to identify anomalous data points, as well as compared with imagery and NOAA Raster Nautical Charts. If necessary, persistent anomalies were cleaned from the input source data and the DEM tile was re-generated using the previously described processes.

A pilot-study on estimating the DEM vertical uncertainty at the individual cell-level was conducted for a 1-9th arc-second tile (extents: -82.50 W to -82.25 W; 26.75 N to 27.00 N). The cell-level estimate of the potential vertical error considers uncertainty from the source measurement, vertical datum transformation, and interpolation in cells not constrained by measurements. A detailed description of the methodology and results will be submitted for publication in the coming months. For details on estimating interpolation uncertainty, see Amante and Eakins, 2016.

For more information, contact dem.info@noaa.gov

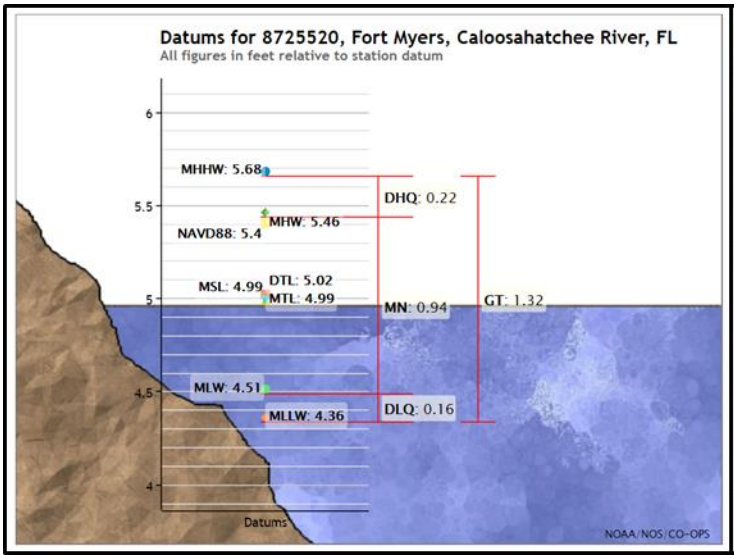
References:

Amante, C.J. and Eakins, B.W., 2016. Accuracy of interpolated bathymetry in digital elevation models. *In*: Brock, J.C., Gesch, D.B., Parrish, C.E., Rogers, J.N., and Wright, C.W. (eds.), *Advances in Topobathymetric Mapping, Models and Applications. Journal of Coastal Research*, Special Issue, No. 76, pp.122-133.

Carignan, K.S.; Taylor, L.A.; Eakins, B.W.; Caldwell, R.J; Friday, D.Z.; Grothe, P.R. and Lim, E., 2011. Digital Elevation Models of Central California and San Francisco Bay: Procedures, Data Sources and Analysis. *NOAA Technical Memorandum NESDIS NGDC-52*, 49p.

Eakins, B.W., Danielson, J.J., Sutherland, M.G., McLean, S.J., 2015. A framework for a seamless depiction of merged bathymetry and topography along U.S. coasts. *Proceedings of the U.S. Hydro Conference* (National Harbor, MD, March 16-19), 10p.

Appendix I – Schematic of measured vertical datum offsets at NOAA tide gauge 8725520



Elevations on Station Datum

Station: 8725520, Fort Myers, Caloosahatchee River, FL
T.M.: 75
Epoch: 1983-2001
Status: Accepted (Apr 17 2003)
Datum: STND
Units: Feet

Datum	Value	Description
MHHW	5.68	Mean Higher-High Water
MHW	5.46	Mean High Water
MTL	4.99	Mean Tide Level
MSL	4.99	Mean Sea Level
DTL	5.02	Mean Diurnal Tide Level
MLW	4.51	Mean Low Water
MLLW	4.36	Mean Lower-Low Water
NAVD88	5.40	North American Vertical Datum of 1988
STND	0.00	Station Datum
GT	1.32	Great Diurnal Range
MN	0.94	Mean Range of Tide
DHQ	0.22	Mean Diurnal High Water Inequality
DLQ	0.16	Mean Diurnal Low Water Inequality